CALTRANS
ENCROACHMENT PERMITS

GUIDELINES AND SPECIFICATIONS

FOR

HORIZONTAL DIRECTIONAL DRILLING INSTALLATIONS

EFFECTIVE JANUARY 1, 2000, LOCATING AND TRACKING OF THE REAMER DURING THE BACK-REAMING PROCESS IS REQUIRED.

California Department of Transportation
Headquarters Office of Encroachment Permits

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GUIDELINES FOR HORIZONTAL DIRECTIONAL DRILLING TECHNOLOGY

HDD GUIDELINES & SPECIFICATIONS

PERMIT APPLICATION SUBMITTAL

The permit application package should contain the following information in support of the permit application.

1. Location of entry and exit point.
2. Equipment and pipe layout areas.
3. Proposed drill path alignment (both plan & profile view).
4. Location, elevations and proposed clearances of all utility crossings and structures.
5. Proposed Depth of cover.
6. **Soil analysis.
7. Product material (HDPE/steel), length, diameter-wall thickness, reamer diameter.
8. Detailed pipe calculations, confirming ability of product pipe to withstand installation loads and long term operational loads including H20.
9. Proposed composition of drilling fluid (based on soil analysis) viscosity and density.
10. Drilling fluid pumping capacity, pressures, and flowrates proposed.
11. State right-of-way lines, property, and other utility right-of-way or easement lines.
12. Elevations.
13. Type of tracking method/system.
14. Survey Grid establishment for monitoring ground surface movement (settlement or heave) due to the drilling operation.

Note: ** *May be waived by the District Permit Engineer on HDD jobs of less than 200mm (6") in diameter and on a transverse crossing less than 150' in length.*

ALL ADDITIONAL PERMIT CONDITIONS SHALL BE SET FORTH IN THE SPECIAL PROVISIONS OF THE PERMIT.

The following, outlines recommended depths for various pipe diameters:

RECOMMENDED MINIMUM DEPTH OF COVER	
DIAMETER	**DEPTH OF COVER**
50mm (2 inches) to 150mm (6 inches)	1.2 meters (**4** feet)
200mm (8 inches) to 350mm (14 inches)	1.8 meters (6 feet)
375mm (15 inches) to 600mm (24 inches)	3.0 meters (10 feet)
625mm (25 inches) to 1200mm (48 inches)	4.5 meters (15 feet)

The permittee/contractor shall, prior to and upon completion of the directional drill, establish a Survey Grid Line and provide monitoring.

Upon completion of the work, the permittee shall provide an accurate as-built drawing of the installed pipe.

SOIL INVESTIGATIONS

A soil investigation should be undertaken, suitable for the proposed complexity of the installation to confirm ground conditions.

Definition: Soil Analysis

Common sense must be utilized when requiring the extensiveness of the soil analysis. A soil analysis is required in order to obtain information on the ground conditions that the contractor will encounter during the HDD operation.

If, the contractor can go to the project site and do an excavation with a backhoe to one foot below the proposed depth of the bore, that is a soil investigation. In all cases when an excavation is made in creating of an entrance and exit pit for a HDD project, that is an example of a soil investigation. The HDD process is in itself a continual and extensive soil analysis as the pilot bore is made and it encounters the varying soils and formations the drilling slurry will change colors, therefore providing the contractor with continual additional information.

The purpose and intent of the soil analysis is to assist the contractor in developing the proper drilling fluid mixture, and to ensure Caltrans that the contractor is aware of the conditions that do exist in the area of the proposed project. This prepares the contractor in the event they should encounter a zone of pre-tectonics, and that they would need additives or preventive measures in dealing with inadvertent returns (frac-outs).

The discretion on the extensiveness of the soil analysis is left to each individual District Permit Engineer (DPE) respectfully, for their respective areas. The inspectors play a large role in assisting the DPE in making decisions on the extensiveness. Each individual inspector has a general knowledge of the soil conditions in their area of responsibility.

In many circumstances the soil information has already been prepared, either by Caltrans or by City and County Entities. This information if existing should be provided to the requesting permittee, if there is a structure within 1/2 mile of the proposed project, then Caltrans has already done an extensive soil analysis and the information is stored in our Maps & Records Branch. As-Builts, on our freeways and highways provide stationing and detailed information regarding soil information, cut and fill areas.

Determination of Soil Investigations

The District Permit Engineer (DPE) should determine the extensiveness of the Soil Investigation to be performed based on the complexity of the HDD operation, the DPE may recommend according to the guidelines listed below, a combination of, or modify the guideline to fit the respective area:

Projects less than 500' in length, where the product or casing is 8" or less in diameter:

A field soil sampling investigation to a depth of one foot below the proposed drilling.

a) subsurface strata, fill, debris and material

Projects less than 800' in length, where the product or casing is 14" or less in diameter:

A field soil sampling investigation to a depth of one foot below the proposed drilling.

a) subsurface strata, fill, debris and material
b) particle size distribution (particularly percent gravel and cobble)

Projects where the product or casing is 16" or greater in diameter:

A geotechnical evaluation by a qualified soil engineer to determine the following.

a) subsurface strata, fill, debris and material,
b) particle size distribution (particularly percent gravel and cobble),
c) cohesion index, internal angle of friction, and soil classification,
d) plastic and liquid limits (clays), expansion index (clays), soil density
e) water table levels, and soil permeability,

Projects where the product or casing 24" or greater in diameter:

A geotechnical evaluation by a qualified soil engineer to determine the following.

a) subsurface strata, fill, debris and material
b) particle size distribution (particularly percent gravel and cobble)
c) cohesion index, internal angle of friction, and soil classification
d) plastic and liquid limits (clays), expansion index (clays), soil density, and penetration tests,
e) rock strength, rock joint fracture and orientation, water table levels, and soil permeability,
f) areas of suspected and known contamination should also be noted and characterized.

Boreholes or test pits should be undertaken at approximately 75 to 125 meter (250 to 410 feet) intervals where a proposed installations greater than 1000' feet in length and parallel an existing road. For road crossings a borehole or test pit shall be undertaken on either side with one or more additional boreholes or test pits in the median where conditions permit. Additional boreholes or test pits should be considered if substantial variation in soil conditions are encountered.

Should the soil investigation determine the presence of gravel, cobble, and/or boulders, care should be exercised in the selection of drilling equipment and drilling fluids. In such ground conditions the use of casing pipes or washover pipes may be required or specialized drilling fluids utilized. Fluid jetting methods used as a means of cutting **should only be considered** where soils have a high cohesion such as stiff clays.

Directional drilled gravity sewers shall only be considered where suitable soil conditions are present. Suitable soil conditions include homogenous soils consisting of clays, silts, silty sands, and sands that would allow for good control of the drill head during the pilot hole drilling.

PRE-CONSTRUCTION & SITE EVALUATION

The following steps should be undertaken by the permittee/contractor in order to ensure safe and efficient construction with minimum interruption of normal, everyday activities at the site.

1. Notify owners of subsurface utilities along and on either side of the proposed drill path of the impending work through USA alert (the one-call program). All utilities along and on either side of the proposed drill path are to be located.
2. Obtain all necessary permits or authorizations to carry construction activities near or across all such buried obstructions.
3. All utility crossings should be exposed using a hydro-excavation, hand excavation or other approved method (potholing) to confirm depth.
4. Construction schedule should be arranged so as to minimize disruption (e.g. drilling under railroad beds, major highways, and/or river crossings).
5. The proposed drill path should be determined and documented, including its horizontal and vertical alignments and the location of buried utilities and substructures along the path.

The size of excavations for entrance and exit pits should be of sufficient size to avoid a sudden radius change of the pipe, and consequent excessive deformation at these locations. Sizing the pits is a function of the pipe depth, diameter and material. All pits, over 5' in depth must be shored as required by OSHA regulations.

Walk the area prior to the commencement of the project and visually inspect potential sites. The following should be addressed:

1. When on State R/W establish whether or not there is sufficient room at the site for: entrance and exit pits; HDD equipment and its safe unimpeded operation; support vehicles; fusion machines; stringing out the pipe to be pulled back in a single continuous operation.
2. Establishing suitability of soil conditions for HDD operations (The HDD method is ideally suited for soft sub-soils such as clays and compacted sands. Subgrade soils consisting of large grain materials like gravel, cobble, and boulders make HDD difficult to use and may contribute to pipe damage).
3. Check the site for evidence of substructures such as manhole covers, valve box covers, meter boxes, electrical transformers, conduits or drop lines from utility poles, and pavement patches. HDD may be a suitable method in areas where the substructure density is relatively high.

INSTALLATION REQUIREMENTS

The permittee shall ensure that appropriate equipment is provided to facilitate the installation, in particular the drill rig shall have sufficient pulling capacity to meet the required installation loads determined by the detailed pipe calculations. The drill rig should have the ability to provide pull loads, push loads, torque and the permittee shall ensure that they are monitored during the drilling operation. The permittee shall ensure the drill rod can meet the bend radii required for the proposed installation (a general rule of thumb is 100 times in feet, the diameter of the drill pipes).

During construction continuous monitoring and plotting of pilot drill progress shall be undertaken to ensure compliance with the proposed installation alignment and allow for appropriate course corrections to be undertaken that would minimize “dog legs” should the bore start to deviate from the intended bore path.

Monitoring shall be accomplished by manual plotting based on location and depth readings provided by the locating/tracking system or by computer generated bore logs which map the bore path based on information provided by the locating/tracking system. Readings or plot points shall be undertaken on every drill rod.

For gravity sewer installations or installations where tight control of alignment and grade is required readings shall be undertaken every 1.0 to 1.5 meters (3 to 5 feet). At the completion of the bore an as-built drawing shall be provided. Prior to commencement of a directional drilling operation, proper calibration of the sonde equipment shall be undertaken.

Monitoring of the drilling fluids such as the pumping rate, pressures, viscosity, and density during the pilot bore, back reaming, and/or pipe installation stages, shall be undertaken to ensure adequate removal of soil cuttings and the stability of the borehole is maintained. Excess drilling fluids shall be contained at entry and exit points until recycled or removed from the site. Entry and exit pits should be of sufficient size to contain the expected return of drilling fluids and soil cuttings.

The permittee shall ensure that all drilling fluids are disposed of in a manner acceptable to the appropriate local, state, or federal regulatory agencies. When drilling in contaminated ground the drilling fluid shall be tested for contamination and disposed of appropriately. Restoration of damage to any highway or non-highway facility caused by escaping ("fracout") drilling fluid, or the directional drilling operation, shall be the responsibility of the permittee.

To minimize heaving during pullback, the pull back rate shall be determined which maximizes the removal of soil cuttings and minimizes compaction of the ground surrounding the borehole. The pullback rate shall also minimize overcutting of the borehole during the back reaming operation to ensure excessive voids are not created resulting in post installation settlement.

The permittee shall, prior to and upon completion of the directional drill, establish a Survey Grid Line and provide monitoring as outlined in their submitted detailed monitoring plan. Subsurface monitoring points shall be utilized to provide early indications of settlement as large voids may not materialize during drilling due to pavement bridging.

Should pavement heaving or settlement occur, sawcutting and replacement of the asphalt would be the responsibility of the permittee.

To prevent future settlement should the drilling operation be unsuccessful the permittee shall ensure the backfill of any void(s) with grout or backfilled by other means.

THE ABOVE REQUIREMENTS ARE DESCRIBED FURTHER AS FOLLOWS:

1.0 CONSIDERATIONS

1. ***Different ground conditions:*** The availability of adequate geo-technical information is invaluable in underground construction; it acts to reduce the risk born by the permittee/contractor. However, even in the presence of good geo-technical data, unexpected ground conditions may be encountered.

2. ***Turbidity of Water and Inadvertent Returns:*** Prior to construction beginning, while difficult to predict, events may lead to work stoppage. The permittee/contractor should

offer a mechanism to mutually address and mitigate these problems if and when they should arise. For example, contingency plans for containment and disposal of inadvertent returns or frac outs.

2.0 PERMITTEE/CONTRACTOR RESPONSIBILITIES

The permittee/contractor should provide the following items: construction plan; site layout plan; project schedule; communication plan; safety procedures; emergency procedures; company experience record; contingencies plan and drilling fluid management plan.

2.1 CONSTRUCTION PLAN REQUIREMENTS

The permittee shall identify in the construction plan:

1) Location of entry and exit pits.
2) Working areas and their approximate size.
3) Proposed pipe fabrication and layout areas.
4) State right-of-way lines, property lines.
5) Other utility right-of way and easement lines.
6) Pipe material and wall thickness.
7) Location of test pits or boreholes undertaken during the soil investigation.
8) Identify the proposed drilling alignment (both plan & profile view) from entry to exit.
9) Identify all grades and curvature radii.
10) All utilities (both horizontal and vertical).
11) Structures with their clearances from the proposed drill alignment.
12) Confirm the minimum clearance requirements of affected utilities and structures.
13) Required minimum clearances from existing utilities and structures.
14) Diameter of pilot hole, number and size of pre-reams/backreams.
15) Access requirements to site (if required).
16) Crew experience.
17) Type of tracking equipment.

2.2 LOCATING AND TRACKING

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The permittee shall describe the method of locating and tracking the drillhead during the pilot bore. Systems include walkover, wireline, or wireline with wire surface grid. The locating and tracking system shall be capable of ensuring the proposed installation can be installed as intended.

Typical walkover sounds have an effective range of 10 to 15 meters, depending on the Electro-magnetic properties of the soil and the extent of local magnetic interference. Depending on the profile of the borehole, the driller may lose contact with the sound over certain sections of the alignment. If the “blind” section is expected to be too long or in the vicinity of a buried object, the project engineer may specify the use of a wire-line system or a magnetic navigation tool.

The locating and tracking system shall provide the following information:

- Clock and pitch information
- Depth
- Beacon Temperature
- Battery Status
- Position (x,y)
- Azimuth – where direct overhead readings (walkover) are not possible.

Illustration **2.2A** below shows a universal housing that will work with any drill-string on all HDD rigs. The placement of the sonde should be before the backreamer.

This housing can be utilized in the initial pilot bore, after exiting, the cutting head can be removed and the reamer installed.

This housing chamber can utilize any of the sonde batteries manufactured, regardless of manufacturer.

There is also a 2.5" mini-sonde combination available for smaller rigs. This particular model can be seen at the following web site: **www.geologicalboring.com/**

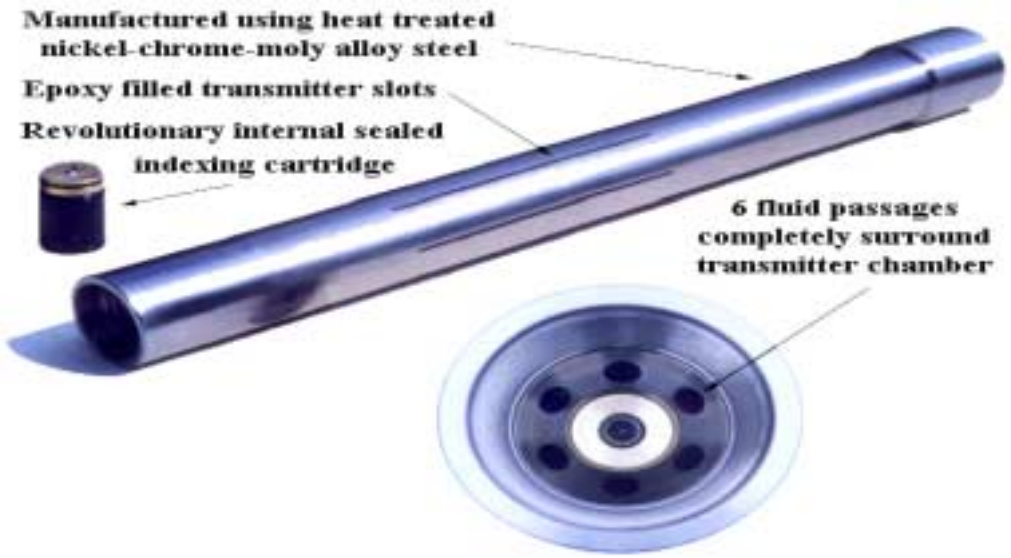

ILLUSTRATION 2.2A

2.3 Drilling Fluids Management Plan

The following information should be provided as part of the drilling fluid management plan:

- Proposed viscosities for soil transportation to the entry and exit pits.
- Estimated pumping capacity and pressures.
- Identify source of fresh water for mixing the drilling mud (Necessary approvals and permits are required for sources such as streams, rivers, ponds, or fire hydrants).
- Method of slurry containment.

- Method of recycling drilling fluid and spoils (if applicable).
- Method of transporting drilling fluids and spoils off site.

Drilling fluid pressures should not exceed that which can be supported by the overburden (soil) pressure.
Drilling fluids serve many functions, as follows:

- Removes cuttings from the bottom of the hole and transports them to the surface.
- Holds cuttings and weight material in suspension when circulation is interrupted.
- Releases sands and cuttings at the surface.
- Stabilizes the hole with an impermeable cake.
- Cools and lubricates the drill bit and drill string
- Controls subsurface pressures.
- Transmits hydraulic horsepower.
- Cools the locating transmitter sonde preventing burnout.

Section 7 provides a more detailed discussion of drilling fluid handling and disposal practices.

2.4 Previous Experience

1. The permittee's contractor should provide a list of projects completed by his company, location, project environment (e.g., urban work, river crossing), product diameter and length of installation.
2. The permittee's contractor should provide a list of key personnel.

2.5 Safety

The drilling unit should be equipped with an electrical strike safety package. The package should include warning sound alarm, grounding mats (if required), and protective gear.

The permittee/contractor should have a copy of the company safety manual including:

2.1 Operating procedures that comply with applicable regulations, including shoring of pits and excavations when required.
2.2 Emergency procedures for inadvertently boring into a natural gas line, live power cable, water main, sewer lines, or a fiber-optic cable, which comply with applicable regulations.
2.3 Emergency evacuation plan in case of an injury.

2.6 Contingency Plans

The Contingency plan should address the following:

a) Inadvertent return, spill (e.g., drilling fluids, and hydraulic fluids), including measures to contain and clean the affected area.
b) clean up of surface seepage of drilling fluids and spoils (i.e., “Frac-out”).

2.7 Communication Plan

The communication plan should address the following:

1. The phone numbers for communication with owner or his representative on the site.
2. Identification of key person(s) which will be responsible for ensuring that the communications plan is followed.
3. Issues to be communicated including safety, progress, and unexpected technical difficulties.

2.8 Traffic Control

1. When required, the permittee/contractor is responsible for supplying and placing warning signs, barricades, safety lights, and flags or flagmen, as required for the protection of pedestrians and vehicle traffic.
2. Obstruction of the roadway, on major road, should be limited to off-peak hours.

3.0 IN ADDITION TO THE PERMIT PACKAGE (IF REQUIRED)

Information that may be required, include other permits, bonding and certification as listed in the following sections.

3.1 Additional Permits that may be required:

1. for obtaining water (ie: hydrants, streams, etc.)
2. for storage, piling and disposal of material.
3. for water/bentonite disposal.
4. Any other permits required carrying out the work.

3.2 Bonding and Certification Requirements

1. Payment bond (if required).
2. Performance bond (if required).
3. Certificate of insurance

4.0 Drilling Operations

The following paragraphs provide general remarks and rules of thumb related to the directional boring method, as well as specific details regarding various stages of the installation process.

4.1 General

1. Drilling mud pressure in the borehole should not exceed that which can be supported by the overburden to prevent heaving or a hydraulic fracturing of the soil (i.e. “Frac-out”). Allowing for a sufficient cover depth does this. Typical bore depth of 0.75m to 1.0m gives pipes with an Outside Diameter (O.D.) of 50-200mm a minimum cover of 0.65m. While circumstances may dictate greater depths, shallower depths are not recommended.
2. The drill path alignment should be as straight as possible to minimize the fractional resistance during pullback and maximize the length of the pipe that can be installed during a single pull.

3. It is preferable that straight tangent sections be drilled before the introduction of a long radius curve. Under all circumstances, a minimum of one complete length of drill rod should be utilized before starting to level out the borehole path.
4. The radius of curvature is determined by the bending characteristics of the product line, and it is increasing with diameter.
5. Entrance angle of the drill string should be between 8 and 20 degrees, with 12 degrees being considered optimal. Shallower angles may reduce the penetrating capabilities of the drilling rig, while steeper angles may result in steering difficulties, particularly in soft soils. A recommended value for the exit angle of the drill string is within the range of 5 to 10 degrees.
6. Whenever possible, HDD installation should be planned so that back reaming and pulling for a leg can be completed on the same day. If necessary, it is permissible to drill the pilot hole and pre-ream one-day, and complete both the final ream and the pull back on the next day.
7. If a drill hole beneath a road must be abandoned, the hole should be backfilled with grout or bentonite to prevent future subsidence.
8. Pipe installation should be performed in a manner that minimizes the over-stressing and straining of the pipe. This is of particular important in the case of a polyethylene pipe.

4.2 Equipment Setup and Site layout

1. Sufficient space is required on the rig side to safely set up and operate the equipment. The workspace required depends on the type of rig used. A small rig may require as little as 3x3m working space, while a large river crossing unit requires a minimum of 30x50m working area. A working space of similar dimensions to that on the rig side should be allocated on the pipe side, in case there is a need to move the rig and attempt drilling from this end of the crossing.
2. If at all possible, the crossing should be planned to ensure that drilling proceed downhill, allowing the drilling mud to remain in the hole, minimizing inadvertent return.
3. Sufficient space should be allocated to fabricate the product pipeline into one string, thus enabling the pull back to be conducted in a single continuous operation. Tie-ins of successive strings during pullback may considerably increase the risk of an unsuccessful installation.

4.3 Drilling and Back-Reaming

1. Drilling mud should be used during drilling and back reaming operations. Using exclusively water may cause collapse of the borehole in unconsolidated soils, while in clays, the use of water may cause swelling and subsequent jamming of the product.
2. Heaving may occur when attempting to back ream too large of a hole. This can be avoided by using several pre-reams to gradually enlarge the hole to the desired diameter.
3. A swivel should be attached to the reamer, or drill rod, to prevent rotational torque being transferred to the pipe during pullback.
4. In order to prevent over stressing of the product during pullback, a weak link, or breakaway-pulling head, may be used between the swirl and the leading end of the pipe. More details regarding breakaway pulling heads can be found in Section 5.
5. The pilot hole must be back-reamed to accommodate and permit free sliding of the product inside the borehole. A rule of thumb is to have a borehole 1.5 times the product outer diameter. This role of thumb should be observed particularly the larger diameter installations (≥ 250mm O.D.). Some recommended values for final pre-ream diameter as

a function of the product O.D. are given in Table II. These values should be increased by 25% if excessive swelling of the soil is expected to occur or the presence of boulders/cobbles is suspected.

Table II: Recommended Back-Ream Hole Diameter (Popelar et al., 1997)

Nominal Pipe Diameter (millimeters)	Back-Ream Hole Diameter (millimeters)
50	75 to 100
75	100 to 150
100	150 to 200
150	250 to 300
200	300 to 350
250	350 to 400
≥300	At least 1.5 times product OD

6. The conduit must be sealed at either end with a cap or a plug to prevent water, drilling fluids and other foreign materials from entering the pipe as it is being pulled back.
7. Pipe rollers, skates or other protective devices should be used to prevent damage to the pipe from the edges of the pit during pullback, eliminate ground drag or reduce pulling force and subsequently reduce the stress on the product.
8. The drilling mud in the annular region should not be removed after installation, but permitted to solidify and provide support for the pipe and neighboring soil.

4.4 Tie-Ins and Connections

1. Trenching may be used to join sections of conduits installed by the directional boring method.
2. An additional pipe length, sufficient for joining to the next segment, should be pulled into the entrance pit. This length of the pipe should not be damaged or interfere with the subsequent drilling of the next leg. The contractor should leave a minimum of 1m of conduit above the ground on both sides of the borehole.

4.5 Alignment & Minimum Separation

The product should be installed to the alignment and elevations shown on the drawings within the pre-specified tolerances (tolerance values are application dependent, for example, in a major river crossing, a tolerance of ±4 m from the exit location along the drill path centerline may be an acceptable value). This tolerance is not acceptable when installing a product line between manholes. Similarly, grade requirements for a water forcemain are significantly different from those on a gravity sewer project.

When a product line is installed in a crowded right-of-way, the issue of safe minimum separation distance arises. Many utility companies have established regulations for minimum separation distances between various utilities. These distances needed to be adjusted to account for possible minor deviation when a line product is installed using HDD technology. As a rule of thumb, if the separation distance between the proposed alignment and the existing line is 5 meters or more, normal installation procedures can be followed. If the separation is 1.5 meters or less, special

measures, such as observation boreholes are required. The range between 1.5 and 5 meters is a "gray" area, typically subject to engineering judgement (a natural gas transmission line is likely to be treated more cautiously than a storm water drainage line).

5.0 BREAK-AWAY PULLING HEAD

Recent reports from several natural gas utility companies reveal concerns regarding failure experienced on HDPE pipes installed by horizontal directional drilling (Troch and Doyle, 1998). These failures were attributed to deformation of the pipe due to the use of excessive pulling force during installation. A mitigation measure adopted by some gas companies involves the use of breakaway swivels to limit the amount of force used when pulling HDPE products. Some details regarding these devices and their applications are given below.

1. The weak link used can be either a small diameter pipe (but same SDR) or specially manufactured breakaway link. The latter consists of a breaking pin with a defined tensile strength incorporated in a swivel. When the strength of the pin is exceeded it will break, causing the swivel to separate. A summary of pulling head specifications is given in Table III (all products are SDR 11). "Note that the values provided in Table III could be considered conservative."

Table III: Pulling Head Specifications (Troch and Doyle, 1998)

Pipe Diameter (in.)	Diameter of Break-Away Swivel (in.)	Maximum Allowable Pulling Force (lb.)
1 ¼	7/8	850
2	1 ¼	1,500
4	1 3/8	5,500
6	2 ½	12,000
8	3	18,500

2. The use of breakaway swivels is particularly warranted when installing small diameter HDPE pipes (up to 4" O.D.). Application of such devices in the installation of larger diameter products is not currently a common practice.
3. If the drilling equipment rated pulling capacity is less than the safe load the use of a weak link may not be required.
4. Exceeding the product elastic limit can be avoided simply by following good drilling practices, namely: regulating pulling force; regulating pulling speed; proper ream sizing; and using appropriate amounts of drilling slurry fluid.

6.0 PROTECTIVE COATINGS

In an HDD installation, the product may be exposed to extra abrasion during pullback. When installing a steel pipe, a form of coating which provides a corrosion barrier as well as an abrasion barrier is recommended during the operation, the coating should be well bonded and have a hard smooth surface to resist soil stresses and reduce friction, respectively. A recommended type of coating for steel pipes is mill applied Fusion Bonded Epoxy.

7.0 DRILLING FLUID - COLLECTION AND DISPOSAL PRACTICES

The collection and handling of drilling fluids and inadvertent returns has been one of the most debated topics, the need to keep drilling fluids out of streams, streets and municipal sewer lines.

1. Drilling mud and additives to be used on a particular job should be identified in the permit package, and their Material Safety Data Sheets (MSDS) should be provided to the Permit Office.
2. Excess drilling mud slurry shall be contained in a lined pit or containment pound at exit and entry points, until recycled or removed from the site. Entrance and exit pits should be of sufficient size to contain the expected return of drilling mud and spoils.
3. Methods to be used in the collections, transportation and disposal of drilling fluids, spoils, and excess drilling fluids should be in compliance with local ordinances, regulations and environmentally sound practices in an approved disposal site.
4. When working in an area of contaminated ground, the slurry should be tested for contamination and disposed of in a manner, which meets government requirements.
5. Precautions should be taken to keep drilling fluids out of the streets, manholes, sanitary and storm sewers, and other drainage systems, including streams and rivers.
6. Recycling drilling fluids is an acceptable alternative to disposal.
7. The contractor shall make all diligent efforts to minimize the amount of drilling fluids and cuttings spilled during the drilling operation, and shall provide complete clean-up of all drilling mud overflows or spills.

8.0 SITE RESTORATION AND POST CONSTRUCTION EVALUATION

1. All surfaces affected by the work shall be restored to their pre-construction conditions. Performance criteria for restoration work will be similar to those employed in traditional open excavation work.
2. If required, the permittee/contractor shall provide a set of as-built drawings including both alignment and profile. Drawings should be constructed from actual field readings. Raw data should be available for submission at any time upon request. As part of the "As-Built" document the contractor shall specify the tracking equipment used, including method or confirmatory procedure used to ensure the data was captured.